

that one bidder might make a combination bid for several bands within some region while another might bid for several regions within the same frequency band. A rule would be necessary to determine who is the winner if each combination bidder were to bid more than the total individual license bids for its combination. If there were conflicts among several bands in multiple geographic regions, this problem could become quite complicated. Not only does this pose the possibility of confusion on the part of the bidders and the Commission, the auction design even with this additional complexity would be unable to ensure that licenses are assigned to those that value them most highly. We comment further on the best of the complex auction designs in section IV of this testimony, but find it, too, to be impractical.

30. In terms of the objectives of the Act, one justification for introducing some bias might be to create a preference for certain designated entities. The Commission's present plan, however, which creates a preference for designated entities using set asides and possibly financing or other special terms, obviates the need to use combination bidding for that purpose.

31. The NPRM suggests a possible remedy for the free rider problem (at paragraph 60). It proposes that after the sealed combination bids are opened, the individual winners from the first round could be offered an opportunity to increase their bids. This remedy, however, is inadequate. In the example of Figure 1, the regional bidders would still need to coordinate to increase both their bids to something over 16. No individual bidder could gain by increasing its bid unilaterally. This coordination problem is still a free rider problem, and it still becomes worse as the number of individual winners increases.

32. Perhaps the most telling argument against combination bidding is that there exists an alternative that avoids all these biases and inefficiencies. This is the simultaneous auction design that we propose in section VI.

IV. ASSESSMENT OF "SECOND-PRICE" AND "VICKREY" AUCTIONS

33. There does exist a method of conducting auctions that, in theory, allows for a mix of combination and individual bidding while still insuring efficient outcomes. The method may be called the "Vickrey auction" after its originator, William Vickrey. This auction method was introduced by Vickrey at the same time that he introduced the second price auction, which is the special case of a Vickrey auction when there is only one object for sale.

34. A second price auction, as described in the NPRM, awards the license in each individual auction to the highest bidder, but charges that bidder a price equal to the second highest bid. Because a bidder's announced value for the license in such an auction affects whether its bid wins but not the price the winner must pay, the bidder is not tempted to understate its valuation in hopes of obtaining a lower price. A bidder can do no better under the rules of the second price auction than to bid its actual maximum willingness to pay for the license.

35. The general Vickrey auction extends the second price auction in several ways. Most importantly, it applies even when there are multiple items

for sale and when there may be economies of scope among them. The rules of the auction are that the items are awarded in a way that maximizes their combined value using the values reported by the bidders. The price paid by a bidder is then determined as the opportunity cost of the items awarded to that bidder—an amount that does not depend on the winner's bid.

36. The theoretical appeal of the Vickrey auction is that if each bidder knows and bids its actual value for various combinations of licenses, the auction would assign the licenses in a way that creates the most value. In addition, the payment system used does provide an incentive for the bidders to bid their actual values. In comparison to this theoretical ideal, any other auction can be described as biased and inefficient, because it allows licenses to be awarded to other than the highest value bidders.

37. Despite these theoretical advantages, we recommend that the Commission does not adopt the Vickrey auction or the second-price auction in this application. There are three main reasons for this recommendation.

38. First, the general Vickrey auction as just described is not transparent. That is, a non-expert could not tell quickly and easily from an examination of the bids which combination of awards maximizes total value, and therefore what the identity of the winning bidders should be. Similarly, a non-expert could not quickly and easily determine the prices to be paid. A dispute over whether the winners and prices were correctly determined could tie up the entire sale in litigation over an extended period of time, while experts testified about whether the rules were applied correctly. The lack of

transparency is a major defect of the general Vickrey auction for practical applications.

39. The second disadvantage of the Vickrey auction is its lack of adequate testing. Although a Vickrey auction does appear to have been tested in the sale of timber parcels in New Zealand, the general Vickrey auction is exceptionally complicated and there is very little actual experience with it. In simpler settings, the second price auction has not been popular, perhaps because of its extreme vulnerability to collusive behavior and manipulation. In a sale of this magnitude and complexity, it could be dangerous to experiment with such an auction design.

40. Third, even the theoretical advantages of the Vickrey mechanism depend on premises that do not apply in this auction. The first such premise is that the bidders know what value they receive from various combinations of licenses. In fact, however, bidders may be uncertain about the value of spectrum and may be willing to learn from the bids of others. A sealed bid auction like the Vickrey auction limits opportunities for such learning. A second premise of the Vickrey auction in the form described above is that the value obtained by a bidder depends only on the licenses acquired by the bidder, and not on the identities of other bidders who have acquired licenses in the same geographic area. Given the differences in product strategies among bidders, that premise is clearly false. This problem could theoretically be accommodated by an even more complicated auction design, but the extra complexity would be tremendous and would add further to the non-transparency of the Vickrey auction design.

41. There are several ways to modify the Vickrey auction that could overcome some, but not all, of these difficulties. For example, one might allow simultaneous sealed bids to be made for individual licenses and certain limited combinations of licenses, perhaps within a given band over certain regions. Such a design would create budgeting problems for bidders with limited financial resources, since the simultaneous auction awards might threaten to exceed their ability to pay. The price determination rule would still be complicated and opaque. Also, the second and third objections to Vickrey auctions listed in the two preceding paragraphs above would still apply.

42. As with combination bidding, the most telling objection to the Vickrey auction is the availability of a better design, namely, the simultaneous auction design proposed in section VI of this testimony, in which prices for all licenses are determined together, with bidders able to watch the prices for all licenses as they rise. When bidders are unsure about the value of spectrum, that design would allow them to learn from their competitors' bids. When they care about the identity of the likely competitors in each market, the simultaneous mechanism allows them to learn the identities of bidders as the auction proceeds. In general, the simultaneous sale mechanism is more robust to variations in the underlying environment than the Vickrey auction, and therefore more appropriate for a situation with this level of complexity. We will return to this comparison in section VI.

V. ASSESSMENT OF SEQUENTIAL BIDDING

43. The NPRM proposes to auction the licenses in sequence, using oral bidding. The practical implementation of an actual oral auction virtually requires that licenses be offered in sequence, in order to limit the complexity of the decision problems that the bidders face. Yet any system of sequencing the sale of licenses suffers from several disadvantages in the context of an auction for the set of licenses being offered by the Commission.

44. First, the value assigned to a particular band of spectrum in a particular geographic region may depend on what other bands of spectrum the bidder can later acquire. In the early rounds of bidding, the bidder must guess about the prices that will have to be paid later to acquire other bands in the same geographic region or to acquire the spectrum at the same bandwidth in other regions. The need for bidders to guess about such things introduces randomness into the allocation process, increases the risks that bidders face, and makes it less likely that the outcome of the auction will be to place licenses in the hands of the bidders with the highest values.

45. A second problem with sequential selling of license rights is that the regional bidders at the early rounds would be at a disadvantage compared to later round bidders, because they would have much less information about the value of spectrum as perceived by the other bidders and therefore the likely price of spectrum in the secondary market. Some early round bidders might hold back for fear of looking silly by paying too high a price. Lack of information would also favor intimidation tactics by large, national bidders,

whose jump bidding might scare off those competing for regional networks covering multiple MTAs by making it appear that the prices will be too high for them to afford.

46. Sequencing also creates unavoidable biases among the regional bidders themselves. As more rounds go by, more information about values, the success of those assembling national networks, and the likely identities of the major competitors and potential network partners will become available to the next round of bidders. In addition, if some network assemblers face budget limits, competition for the later regional licenses might be affected by that, resulting in lower prices for later auctioned licenses. It simply isn't possible to sell licenses in sequence without creating some advantages and disadvantages of that sort.

47. Sequenced auctions also create undesirable strategic possibilities for bidders. For example, a bidder might try to drive up the price paid by its competitor for licenses in the Eastern United States, if those licenses were sold first, in order to drive it near to its budget limit when the auctions for Western licenses finally opens. Such strategies can undermine efficient outcomes, because they can prevent the highest value bidders from winning licenses. Of course, the feasibility of these strategies depends on the order in which the licenses are sold.

VI. ASSESSMENT OF SIMULTANEOUS REPEATED AUCTIONS

48. The simultaneous repeated sealed-bid auction design, which we have

developed, offers a practical alternative that attenuates all of the problems identified above, and completely eliminates most of them. Its rules would be as follows.

49. The auction would be conducted by collecting sealed bids from qualified bidders once per day, late in the afternoon, for all the licenses being offered. Acceptable bids must exceed by some minimum increment, such as five percent (5%), the highest previously posted bid for that license, and must also exceed the minimum bid for the license specified by the Commission. (In case of tied bids, the 5% minimum would be waived on that license on the next day.) The auctioneer would collate the information, and report back to all participants the identities and bids of the highest and second highest bidders on each day, and the number of new bidders. Bids, once made, could not be withdrawn.

50. In addition, bidders would be required to be active every day. A bidder is deemed active on a particular day if its bid on some license from the previous day is highest or if it submits a new bid exceeding the previous high bid for the same license. A bidder that is inactive on some day is deemed to have withdrawn, and is precluded from further bidding.

51. The rule for concluding the auction is the following: if the morning report from the FCC reveals that no license has received a new higher bid, then the FCC announces that upfront payments of 20% are due from the winning bidders by the end of the current business day. Those bidders failing to provide such payments are disqualified from all bidding, all their bids are

deleted and their deposits are forfeit. The next highest bidder is then declared the winner.

52. Several of the details of the rules of our design are important for its effective performance. For one, the rule against withdrawing bids is a critical feature of the design. This rule forces bidders to give careful consideration to their bids during the course of the auction and mitigates the strategic incentive that a bidder might have to bid more than it is actually willing to pay for some particular license in order to drive up the price that a competitor must pay.

53. The rule for ending the auction is similarly important. Laboratory auction experiments regularly demonstrate that fixed time deadlines lead to significant "end effects," in which some bidders do not have time to react to the bids of competitors, while others withhold bids until near the deadline in order to limit the competitive response they may face. In view of the absence of a fixed time limit in our design, the minimum bid increments are necessary to ensure that bidding progresses to a timely conclusion.

54. In the absence of a fixed deadline, the time needed to complete the auction can only be roughly estimated. If the initial bids are approximately half the level of the final bids for each license, and if bids are raised five percent on each license on each day, then the time required to complete the auction would be fourteen business days. If there is a cascade effect with active bidding on one group of licenses occurring earlier followed by active bidding on another group, then the time required for the auction to conclude

could be multiplied by the number of tiers in the cascade.

55. Our design incorporates some aspects of the Commission's preferred oral bidding format. Most importantly, prices would ascend to the level determined by "open" competition, that is, competition in which the identities of the bidders and amounts of the bids are public information.

56. We think it is desirable that the identities of at least the current two highest bidders be revealed. Revelation can enhance efficiency if the identity of a firm's competitors in a given market has an impact on its value of the license. Such an impact is an inevitable consequence of the economies of scale and scope in the PCS industry, which lead each bidder to be concerned about the products and relative costs of its competitors, and whether they reflect such economies. On the other hand, there is some prospect that revelation of bidders' identities could facilitate collusion. Our view is that there already exist adequate sanctions against collusion.

57. From the auctioneer's perspective, the main practical problem in implementing this auction is the data processing requirement of accepting the thousands of simultaneous sealed bids for licenses that would be submitted daily. In constructing the details of our design, we have been mindful of the need to avoid relying on sophisticated new software, which might not be adequately developed and tested in time to conduct the auction next Spring. The bid processing needed for our design would not require the use of specialized auction software, because the problem is simply one of collating the bids and reporting back the information described above. One possibility

is to require that bids be submitted in a format that can be input electronically into a standard spreadsheet program, such as Excel or Lotus. Each row of the spreadsheet could correspond to a license and each column to a bidder, and the desired bid information each day could be computed quickly and returned to the bidders for assessment during the next day. Standard database programs might work equally well. Because the required arithmetic operations are elementary ones and several implementation options are available, the problem of designing and testing such a system before the auction date appears to be quite manageable. Also, the FCC could reserve the right to slow the pace of the auction and process bids by hand in case of software reliability problems.

58. If appropriate software is available, then a continuous electronic auction might be implemented as an alternative to our repeated sealed-bid design. It would operate according to much the same rules as the repeated sealed bid design, except that new bids, instead of being restricted to be submitted only once per day, could be submitted electronically at any time. Information, instead of being returned to bidders once per day, would be posted continuously on a public electronic bulletin board. This design, if technically feasible, would share the same advantages as the design described earlier. In addition, we expect that it would allow the auction to be concluded more quickly, because it would allow bidders to respond to competitors' bids more quickly, but without forcing the bidders to do so.

59. A comparison to other possible auction designs shows that our design has several advantages and avoids the worst of the defects suffered by the

alternative designs. Here is a partial list:

60. First, by avoiding combination bidding, our design avoids creating the inefficient bias in favor of combination bidders that we identified earlier. In particular, it avoids the bias in favor of national bidders that would be created by proposed national combination bidding in paragraph 120 of the NPRM. By ensuring that all bidders have equal opportunities to win the auction of each license, it provides the strongest prospect that the licenses are awarded to the highest value bidders.

61. Second, by avoiding sequencing, the design allows those whose strategies call for assembling large geographic networks to implement their strategies in each region and reduces their need to guess about the prices that will prevail for licenses in other regions. This design also avoids the other disadvantages of sequenced bidding described above, including the tendency of such designs to favor some groups of regional and local bidders over others.

62. Third, in contrast with one-round simultaneous sealed-bid designs, our design allows bidders to pursue a much richer array of contingent bidding strategies. For example, it allows bidders to plan to bid first on one license or for licenses to construct one kind of network, with a fallback position in case that license or network proves to be too expensive. The rule against withdrawing bids would limit the amount of switching and falling back that a bidder could do, ensuring that the auction would be completed within a reasonable period of time.

63. Fourth, in comparison with a fully electronic continuous market mechanism, our design does not require developing and testing new specialized auction software. It can be implemented using standard spreadsheets or database programs along with an appropriate means of communicating bids. If appropriate specialized auction software can be made ready in the available time, then that software could be used to implement the variation of our design described above.

64. Fifth, in comparison to a one-round simultaneous sealed-bid design, our design would eliminate the need to have special provisions to deal with budget limits, or with the desire or requirement of bidders to limit the bandwidth they purchase in a single region, and any similar restrictions. Bidders could account for such things as budget limits in the same way that they account for economies of scope and scale during the course of the auction, by bidding first on the licenses they most desire and only later, budget permitting, on their less favored choices. Since bidding for all licenses would close at the same time, this switching would be quite feasible and would impose no hardship on bidders with limited budgets.

65. Sixth, unlike Vickrey auctions, the pricing mechanism in the proposed simultaneous design would be simple and transparent: the highest bidder wins and pays the amount of its bid.

66. There are several possible variations on our basic design that have some potential merits, depending on the criteria being applied in making the

evaluation. One variation would differ only in having the auctioneer conceal the identities of the bidders at each round. Although concealing identities has the advantage of making implicit collusion more difficult, revealing identities has the advantage of allowing bidders to assess the situation in each individual license market and to draw contingency plans. In recommending our basic design, we have assumed that the level of competition and the presence of other safeguards will be sufficient to make collusion unlikely.

67. A second variation would separate the sales of MTA and BTA licenses, with MTA licenses being sold first. This variation would still permit bidders who failed to win sufficient MTA licenses to complete regional or national systems using BTA licenses. Also, bidders for BTA licenses could utilize the information about the identities of the MTA licensees in assessing their valuations of local BTA licenses. However, because this design limits price comparisons between the two kinds of licenses, it suffers some of the same disadvantages as other sequenced selling designs, though in more limited degree.

68. The closure rule described above is designed to offer the maximum opportunities for full realization of economies of scale and scope in assembling combinations of licenses. It does this by delaying closure until bidding is complete for all licenses. This can be important because bidders will typically need to adjust their strategies as the bidding proceeds, trying first for a most desirable combination, and then if that fails to follow one or more backup plans.

69. The closure rule allows the possibility that the auction could last for several weeks. We think that this provision is important because the bidders need time to adjust their plans as events unfold. Their bids may amount to tens or hundreds of millions of dollars, and after the auction, the industry structure will be largely fixed for several years. Since so much is at stake, it is likely that management will need to confer with the Board of Directors at several junctures to reassess authorizations for expenditures of such large sums. In sum, to obtain full efficiency, our design proposes to allow the auction to proceed slowly and to last for a considerable duration, perhaps several weeks. This is entirely in keeping with recent experience in other auctions of very large, complex enterprises. Currently, the Board of Paramount is auctioning the firm to the bidders (Viacom, or QVC) in an auction that allows weeks between bids. The auction of RJR Nabisco to its bidders (a management team, or KKR) proceeded similarly at a slow pace. The evidence from these auctions of corporate entities indicates that allowance of ample time for reconsideration and reevaluation is an important ingredient in auctions of complex entities even when there is just one object for sale and just two bidders. It is surely no less important when many licenses are auctioned to many bidders. Moreover, the interest of the corporate boards in obtaining maximum revenue for their shareholders is closely analogous to the Commission's objectives in ensuring efficient development of PCS and realizing the full potential revenue from the auction of licenses.

70. We have considered several alternative closing rules to speed the closing of the auction. However, in every case, the speedy closing of the auctions could interfere with bidders' deliberate consideration of their strategies. For instance, it might require each bidder to adopt initially a

single reservation-price strategy for each license and pursue it relentlessly, with few opportunities to revert to backup strategies. We anticipate that alternative designs to force quick closure of the auction could be very costly in terms of both revenue and the efficiency of the final allocation of licenses.

VII. SECONDARY MARKET TRANSACTIONS

71. Regardless of the auction design, it is likely that some inefficiencies in the allocation of licenses will become apparent after the auction. These may result from changes in technologies, estimates of demand, business alliances, financial conditions, and so on, or simply from errors in bidding decisions in the initial auction. The secondary market provides valuable flexibility, allowing licenses to be reassigned as necessary. We favor unrestricted operation of these markets.

72. Despite the advantages that the secondary market provides, it should not be expected that this market can correct every inadequacy of the initial auction design. The difficulties that complicate the initial auction sale will continue to operate in the secondary market, and there may be additional complications as well. For example, while a bidder in the initial auction sale might expeditiously pursue a strategy of developing a national network within a single band, acquiring the necessary licenses in the secondary market would be problematic. The holder of an individual MTA license in that band could hold out for a very high price, delaying or perhaps blocking the

transaction.

73. We point out these limitations of the secondary market in order to emphasize the importance of getting the allocation at least nearly right the first time. Getting the allocation nearly right the first time requires substantial information processing, and our design encourages that. It does so more than any alternative design proposed in the NPRM.

VIII. INFORMATION, EXPERIMENTATION AND TESTING

74. The key to success in these auctions is active competition among well informed bidders. To the extent that some bidders are better informed than others, the less informed bidders will tend to bid less aggressively, for fear of paying too high a price. Such an outcome is undesirable in several ways. It would disadvantage smaller bidders, whose information sources may be less developed. It would reduce the government's likely receipts, by discouraging some bidders. Finally, it would undermine the objective of awarding licenses to those with the highest actual values, and instead tend to award licenses to bidders with more accurate information.

75. To ensure the efficient allocation of licenses, increased revenues, and encourage smaller bidders, the Commission should pursue an aggressive program of gathering and disseminating information about the licenses being offered. For example, bidders should be informed about interference in the band from other uses and the prospects for relocating existing users.

76. We are cognizant that our proposal contains novel elements. We encourage the Commission to adopt a staged implementation, beginning with auctions of lower-valued narrowband spectrum and proceeding to broadband auctions at a later stage.

77. Regardless of which auction design is adopted by the Commission for the initial auctions, we recommend that the several leading designs be tested in an experimental laboratory setting. There now exist laboratories for experimental economics at several universities where the procedures for the auction can be simulated on a small scale. Experience with the conduct and results of the auction in a controlled environment can be valuable in anticipating and correcting deficiencies in the design and its operational procedures.

78. Further, because the FCC and other governmental agencies will continue to use auctions in the future, comparisons between the experimental results and the actual results from the auction will be of great value in calibrating the experimental results. This will enable the designs of auctions on subsequent occasions to be pre-tested experimentally with greater confidence in their predictive accuracy.

CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

No. 5193

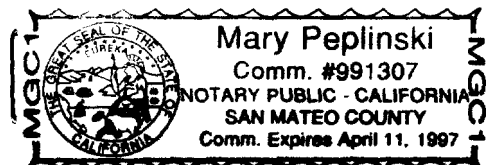
State of California

County of San Mateo

On November 8, 1993 before me, Mary Peplinski, Notary Public
DATE NAME, TITLE OF OFFICER - E.G., "JANE DOE, NOTARY PUBLIC"

personally appeared Paul R. Milgrom
NAME(S) OF SIGNER(S)

☐ personally known to me - OR - ☒ proved to me on the basis of satisfactory evidence to be the person ~~(or whose name is)~~ subscribed to the within instrument and acknowledged to me that he ~~/she/they~~ executed the same in his ~~/her/their~~ authorized capacity ~~(ies)~~, and that by his ~~/her/their~~ signature ~~(s)~~ on the instrument the person ~~(s)~~, or the entity upon behalf of which the person ~~(s)~~ acted, executed the instrument.



WITNESS my hand and official seal.

Mary Peplinski
SIGNATURE OF NOTARY

OPTIONAL SECTION

CAPACITY CLAIMED BY SIGNER

Though statute does not require the Notary to fill in the data below, doing so may prove invaluable to persons relying on the document.

- ☐ INDIVIDUAL
☐ CORPORATE OFFICER(S)

- TITLE(S)
☐ PARTNER(S) ☐ LIMITED
☐ GENERAL
☐ ATTORNEY-IN-FACT
☐ TRUSTEE(S)
☐ GUARDIAN/CONSERVATOR
☐ OTHER: _____

SIGNER IS REPRESENTING:

NAME OF PERSON(S) OR ENTITY(IES)

OPTIONAL SECTION

THIS CERTIFICATE MUST BE ATTACHED TO THE DOCUMENT DESCRIBED AT RIGHT:

Though the data requested here is not required by law, it could prevent fraudulent reattachment of this form.

TITLE OR TYPE OF DOCUMENT _____

NUMBER OF PAGES _____ DATE OF DOCUMENT _____

SIGNER(S) OTHER THAN NAMED ABOVE _____

CALIFORNIA ALL-PURPOSE ACKNOWLEDGMENT

No. 5193

State of California
County of San Mateo

On November 8, 1993 before me, Mary Peplinski Notary Public
DATE NAME, TITLE OF OFFICER - E.G., "JANE DOE, NOTARY PUBLIC"

personally appeared Robert B. Wilson
NAME(S) OF SIGNER(S)

☐ personally known to me - OR - ☒ proved to me on the basis of satisfactory evidence to be the person(~~s~~) whose name(~~s~~) is/~~are~~ subscribed to the within instrument and acknowledged to me that he/~~she~~/they executed the same in his/~~her~~/their authorized capacity(~~ies~~), and that by his/~~her~~/their signature(~~s~~) on the instrument the person(~~s~~), or the entity upon behalf of which the person(~~s~~) acted, executed the instrument.



WITNESS my hand and official seal.

Mary Peplinski
SIGNATURE OF NOTARY

OPTIONAL SECTION

CAPACITY CLAIMED BY SIGNER

Though statute does not require the Notary to fill in the data below, doing so may prove invaluable to persons relying on the document.

- ☐ INDIVIDUAL
☐ CORPORATE OFFICER(S)

- TITLE(S)
☐ PARTNER(S) ☐ LIMITED
☐ GENERAL

☐ ATTORNEY-IN-FACT

☐ TRUSTEE(S)

☐ GUARDIAN/CONSERVATOR

☐ OTHER: _____

SIGNER IS REPRESENTING:

NAME OF PERSON(S) OR ENTITY(IES)

OPTIONAL SECTION

THIS CERTIFICATE MUST BE ATTACHED TO THE DOCUMENT DESCRIBED AT RIGHT:

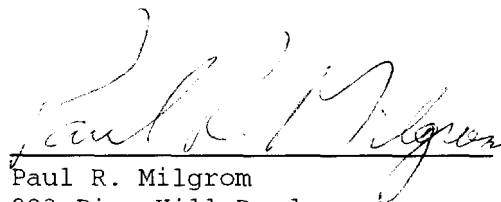
TITLE OR TYPE OF DOCUMENT _____

NUMBER OF PAGES _____ DATE OF DOCUMENT _____

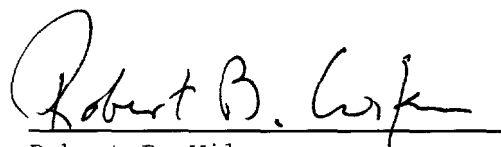
Though the data requested here is not required by law, it could prevent fraudulent reattachment of this form.

SIGNER(S) OTHER THAN NAMED ABOVE _____

Respectfully submitted,



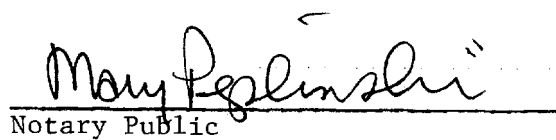
Paul R. Milgrom
823 Pine Hill Road
Stanford, CA 94305



Robert B. Wilson
908 Cottrell Way
Stanford, CA 94305

Date: November 8, 1993

Subscribed and sworn to before me
this 8th day of November, 1993


Notary Public

My Commission Expires April 11th, 1997.